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MODELING AND SIMULATION OF ELEMENTARY MATHEMATICS USING VISUAL BASIC.NET

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Abstract

Students at the lower level of education find learning elementary mathematics quite challenging and daunting. However, learning mathematics is a mandatory prerequisite towards learning other subjects at school. It has been observed that the use of computer programs in teaching elementary mathematics as Computer Aided Instruction (CAI) stimulates student learning and increase their understanding. This paper studies the use of Visual Basic.Net to simulate elementary mathematics. A program that could be used as CAI is developed. The proposed application uses Visual Basic 2010 to model and simulate some elementary mathematics, such as simultaneous and quadratic equations and mean, variance and standard deviation. To test the effectiveness of the program in meeting its objectives, an experiment was performed whereby a class of Junior Secondary Students 2 (JSS2) was split into two groups: an experimental group and a control group. A pre-test was carried out to ensure the equivalence of the two groups. The pretest result shows no significant difference in the performance level of the two groups. The experimental group was then taught the elementary topics: simultaneous and quadratic equations and mean, variance and standard deviation while the control group was taught with the classical method of teaching mathematics. A post-test was conducted to measure the effectiveness of the proposed application in meeting its objectives. The results revealed a significant impact the application has in boosting mathematical performance of the students. This elementary mathematics simulation software used in teaching will go a long way in stimulating students' interest and increasing their performance in elementary mathematics.

Keywords: Simulation, modeling, visual basic, mathematics.

Introduction

Simulation has been defined as the imitation of the operation of a real-world process or system over time to develop a set of assumptions of mathematical, logical and symbolic relationships between the entities of interest and of the system to estimate the measures of performance of the system with the simulation-generated data (Banks, Carson II, Nelson & Nicol, n.d.). The use of simulation as an analysis tool for predicting the effects of the changes to existing systems and as a design tool to predict the performance of new systems has also been reported by Banks, *et al*. (n.d.). When we represent a system for the purpose of studying the system, we referred to that as modeling (Banks *et al*., n.d.). With a model, we simplify a system sufficiently detailed to enable valid conclusions to be drawn about the real system (Banks *et al*., n.d.).

Computer simulation is a powerful alternative approach to solve elementary mathematics using a high level programming language of choice. Simulation is a very useful research tool and is a legitimate, disciplined approach to scientific investigation. Its value needs to be recognized and appreciated. Simulation analysis offers a variety of benefits: it can be useful in developing theory and in guiding empirical work. It can provide insight into the operation of complex systems and explore their behavior. It can examine the consequence of theoretical arguments and assumptions generate alternative explanations and hypothesis and test the validity of explanations (Hassan *et al*., 2006).

Problem Statement

Students at lower level of education find learning elementary mathematics boring and cumbersome. They immediately lose interest as soon as the word 'mathematics' is mentioned to them. Learning mathematics is a mandatory prerequisite towards learning other subjects in the school. Hence, learning it becomes a necessary evil.

Research Motivation

According to MT, *et al.*, (2014), mathematics software improves students' elementary mathematics performance at different levels. Mathematical programming involves practical activities and, therefore, stimulates students learning (Azizu, 2015). When it comes to solving complex mathematical problems, the application of rigorous analytical techniques is time consuming and limited (Azizu, 2015). Computation can be applied for much complex problems with the present efficiency of hardware and software (Hassan *et al*., 2006). The enhanced computation speed of the computer will enable students to explore more complex and difficult problems for their learning (Azizu, 2015).

Modeling and Simulation

According to Banks, *et al*., (n.d.), simulation is appropriate in the following situations:

a. As a pedagogical device, simulation reinforces analytic solution methodologies.

b. Analytic solutions are verified via simulation.

c. Requirements can be determined by simulating different capabilities for a machine.

d. The modern system is so complex that the interactions can only be studied via simulation.

The advantages of simulation, according to Banks, *et al*., (n. d.), include:

a. Simulation can also be used to study systems in the design stage.

b. Simulation models are run rather than solved.

c. New hardware designs, physical layouts, transportation systems can be tested without committing resources for their acquisition.

d. Hypotheses about how or why certain phenomena occur can be tested for feasibility.

The Models of a System

A model is defined as a representation of a system for the purpose of studying the system (Banks *et al*., n. d.). It is necessary to consider only those aspects of the system that affect the problem under investigation (Banks *et al*., n. d.). These aspects are represented in a model, and by definition it is a simplification of the system (Banks *et al*., n. d.).

Types of Models

The various types of models are according to Banks *et al*., (n. d.):

a. The Mathematical or Physical Model

b. The Static Model

c. The Dynamic Model

d. The Deterministic Model

e. The Stochastic Model

f. The Discrete Model

g. The Continuous Model

a. The Mathematical Model

In the mathematical model, symbolic notation and mathematical equations are used to represent a system (Banks, *et al*., n. d.).

b. The Static Model

In the static model, a system at a particular point of time is represented (Banks *et al*., n. d.). It is also known as Monte-Carlo simulation (Banks *et al*., n. d.).

c. The Dynamic Model

In the dynamic model, systems as they change over time are represented (Banks *et al*., n. d.). An example is the simulation of a bank (Banks *et al*., n. d.).

d. The Deterministic Model

The deterministic model contains no random variables (Banks *et al*., n. d.). It has a known set of inputs, which will result in a unique set of outputs (Banks *et al*., n. d.). An example is the simulation of the arrival of patients to the dentist at the scheduled appointment time (Banks *et al*., n. d.).

e. The Stochastic Model

The stochastic model has one or more random variable as inputs (Banks *et al*., n. d.). Random inputs lead to random outputs (Banks *et al*., n. d.). An example of the simulation of a bank involves random inter-arrival and service times (Banks *et al*., n. d.).

2.1.2 Discrete-Event System Simulation

This is the modeling of systems in which the state variable changes only at a discrete set of points in time (Banks *et al*., n. d.). The simulation models are analyzed by numerical rather than analytical methods (Banks *et al*., n. d.). Analytical methods employ the deductive reasoning of mathematics to solve the model (Banks *et al*., n. d.). For example, differential calculus can be used to determine the minimum cost policy for some inventory models (Banks *et al*., n. d.). Numerical methods use computational procedures and are 'runs', which is generated based on the model assumptions and observations are collected to be analyzed and to estimate the true system performance measures (Banks *et al*., n. d.).

Steps to be Taken in a Simulation Study

a. **Problem formulation:** Every study begins with a statement of the problem, provided by policy makers (Banks *et al*., n. d.). The analyst ensures that it is clearly understood (Banks *et al*., n. d.). If it is developed by the analyst, policy makers should understand and agree with it (Banks *et al*., n. d.).

b. **Setting objectives and the overall project plan:** The objectives indicate the questions to be answered by simulation (Banks *et al*., n. d.). At this point, a determination should be made concerning whether simulation is the appropriate methodology (Banks *et al.*, n. d.). Assuming it is appropriate, the overall project plan should include: a statement of the alternative systems, a method for evaluating the effectiveness of these alternatives, the plans for the study in terms of the number of people involved, the cost of the study, and the number of days required to accomplish each phase of the work with the anticipated results (Banks *et al*., n. d.).

c. **Model conceptualization:** The construction of a model of a system is probably as much art as science (Banks *et al*., n. d.). The art of modeling is enhanced by the ability to abstract the essential features of a problem, to select and modify basic assumptions that characterize the system and to enrich and elaborate the model until a useful approximation results (Banks, *et al*., n. d.). Thus, it is best to start with a simple model and build toward greater complexity (Banks *et al*., n. d.). Model conceptualization enhances the quality of the resulting model and increases the confidence of the model user in the application of the model (Banks *et al*., n. d.).

d. **Data collection:** There is a constant interplay between the construction of model and the collection of needed input data (Banks *et al.*, n. d.). Data collection happens at the early stages (Banks *et al*., n. d.). Objective kind of data is collected (Banks *et al*., n. d.).

e. **Model translation:** Real-world systems result in models that require a great deal of information storage and computation (Banks *et al*., n. d.). It can be programmed by using simulation languages or special purpose simulation software (Banks *et al*., n. d.). Simulation languages are powerful and flexible (Banks *et al*., n. d.).

f. **Verified:** It pertains to the computer program and checking the performance (Banks *et al*., n. d.). If the input parameters and logical structure and correctly represented, verification is completed (Banks *et al*., n. d.).

g. **Validated**: It is the determination that a model is an accurate representation of the real system (Banks *et al*., n. d.). This is achieved through the calibration of the model, which is an iterative process of comparing the model to actual system behavior and noting the discrepancies between the two (Banks *et al*., n. d.).

h. **Experimental design:** The alternatives that are to be simulated must be determined. Which alternatives to simulate may be a function of runs. For each system design, decisions need to be made concerning: the length of the initialization period, the length of simulation runs, the number of replication to be made of each run, etc. (Banks *et al*., n. d.).

i. **Production runs and analysis:** This is use to estimate the measures of performance for the system designs that are being simulated (Banks *et al*., n. d.).

j. **More runs:** Based on the analysis of runs that have been completed, the analyst determines if additional runs are needed and what design those additional experiments should follow (Banks *et al*., n. d.).

k. **Documentation and reporting:** There are two types of documentation (Banks *et al*., n. d.): **(a)** program documentation **and (b)** process documentation

Program documentation can be used again by the same or different analysts to understand how the program operates. Further modification will be easier. Model users can change the input parameters for better performance. However, process documentation gives the history of a simulation project. The result of all analysis should be reported clearly and concisely in a final report. This enables reviewing the final formulation and alternatives, results of the experiments and the recommended solution to the problem. The final report provides a vehicle of certification (Banks *et al*., n. d.).

l. **Implementation:** If the model user has been thoroughly involved and understands the nature of the model and its outputs, the likelihood of a vigorous implementation is enhanced (Banks *et al*., n. d.).

Simulation Softwares

According to Banks *et al*., (n. d.), Simulation software is categorized into:

a. **General-Purpose Programming Languages:** These are flexible and familiar and well suited for learning Discrete Event System Simulation principles and techniques (Banks *et al*., n. d.). Examples are: C, C++, Java and Visual Basic.Net (Banks *et al*., n. d.).
b. **Simulation Programming Languages:** These include GPSS, SIMAN, etc.
c. **Simulation Languages (Simulation Environments):** These simulation environments are good for building models quickly. They provide built-in features (e.g., queue structures), graphics and animation. Examples are Arena, Automod, etc (Banks *et al*., n. d.).

According to Banks *et al*., (n. d.), simulation software is selected based on the following factors:

a. Model building feature
b. Runtime environment
c. Animation of layout features
d. Output features
e. Vendor support and product documentation

Visual Basic.Net

Visual Basic.NET evolved from BASIC (Beginner's All-Purpose Symbolic Instruction Code). Visual Basic appeared in 1991. Although Visual Basic is derived from the BASIC programming language, it is a distinctly different language that offers such powerful features as graphical user interfaces, event handling and access to the *Windows 32-bit Application Programming Interface* (*Win32 API*), object-oriented programming and exception handling (Deitel, Deitel, & Nieto). Visual Basic .NET is an event-driven, visual programming language in which programs are created using an *Integrated Development Environment* (*IDE*) (Deitel *et al.*). With the IDE, a programmer can write, run, test and debug Visual Basic programs conveniently, thereby reducing the time it takes to produce a working program to a fraction of the time it would have taken without using the IDE (Deitel *et al.*). The process of rapidly creating an application is typically referred to as *Rapid Application Development (RAD)* (Deitel *et al.*). Visual Basic is the world's most widely used RAD language (Deitel *et al.*). The advancement of programming tools and consumer-electronic devices created many challenges (Deitel *et al.*). Integrating software components from diverse languages proved difficult, and installation problems were common because new versions of shared components were incompatible with old software (Deitel *et al.*). Developers also discovered they needed Web-based applications that could be accessed and used via the Internet. As programmable devices, such as *personal digital assistants* (*PDA*s) and cell phones grew in popularity in the late 1990s, the need for these components to interact with others via the Internet rose dramatically (Deitel *et al.*). As a result of the popularity of mobile electronic devices, software developers realized that their clients were no longer restricted to desktop users (Deitel *et al.*). Developers recognized the need for software accessible to anyone from almost any type of device (Deitel *et al.*).

To address these needs, Microsoft announced the introduction of the Microsoft *.NET* (pronounced "dot-net") strategy in 2000 (Deitel *et al.*). The .NET platform is one over which Web-based applications can be distributed to a variety of devices (such as cell phones) and to desktop computers (Deitel *et al.*). The .NET platform offers a new programming model that allows programs created in disparate programming languages to communicate with each other (Deitel *et al.*). Microsoft has designed a version of Visual Basic for .NET (Deitel *et al.*). Earlier versions of Visual Basic did offer object-oriented capabilities, but Visual Basic .NET offers enhanced object orientation, including a powerful library of components, allowing programmers to develop applications even more quickly (Deitel *et al.*). Visual Basic .NET also enables enhanced language interoperability: software components from different languages can interact as never before (Deitel *et al.*). Developers can package even old software to work with new Visual Basic .NET programs (Deitel *et al.*). Also, Visual Basic .NET applications can interact via the Internet, using industry standards, such as the Simple Object Access Protocol (SOAP) and Extensible Markup Language (XML) (Deitel *et al.*). Visual Basic.NET is crucial to Microsoft's .NET strategy, enabling existing Visual Basic developers to migrate to .NET easily (Deitel *et al.*). The advances embodied in .NET and Visual Basic .NET will lead to a new programming style, in which applications are created from components called *Web Services* available over the Internet (Deitel *et al.*). For this research work, we have used Visual Basic.Net the 2010 edition.

Review of Related Works

Conte, *et al*., (1980) did an excellent job on numerical analysis and programming aspect of it when they made uses of FORTRAN IV programming language to make a comparison between analytical method of solving numerical iterations and programming method of solving numerical iterations and came up with a conclusion that programming method of solving numerical iterations using computer was faster than using analytical method and saved time with a very negligible errors or no errors incurred at all. Conte, *et al*., (1980) made uses of FORTRAN IV programming language, which is text-based. Text based language does not allow users to work directly with graphics. This is one disadvantages why the use of FORTRAN IV programming language is not considered for use in this research work, rather Visual Basic programming language was chosen (Hassan *et al*., 2006).

Hassan, *et al*. (2006) applied Visual Basic 6.0 to simulate some numerical iterations. Azizu (2015) also applied Visual Basic 6.0 to simulate some elementary mathematics. However, both their designs have an interface which ais not visually pleasing and interactive as the one we are proposing. Moreover, Visual Basic 6.0 is now a legacy software, meaning that Microsoft has since relinquished its support for Visual Basic 6.0 Integrated Development Environment and programs created using Visual Basic 6.0 are not compatible with Microsoft's current operating systems.

2. THE PROPOSED SIMULATOR

The proposed simulator is an enhancement to the work of Azizu (2015). The proposed simulator uses Visual Basic 2010. The screenshots of the proposed simulator are presented below:

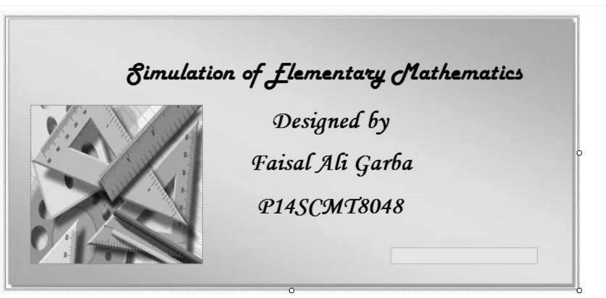

Figure 1: Splash Screen

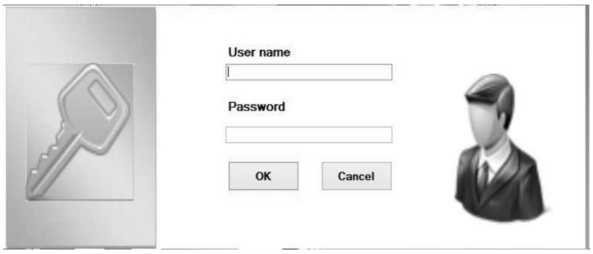

Figure 2: Log- in Screen

Figure 3: Home Page Screen

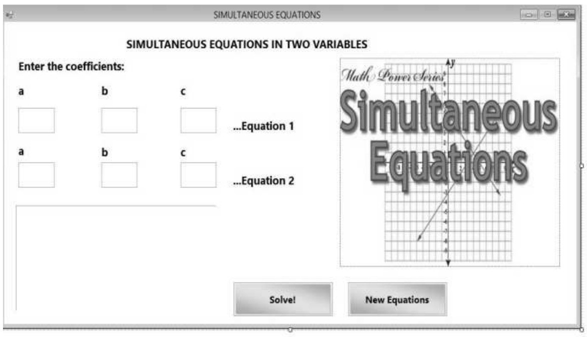

Figure 4: Simultaneous Equations Function

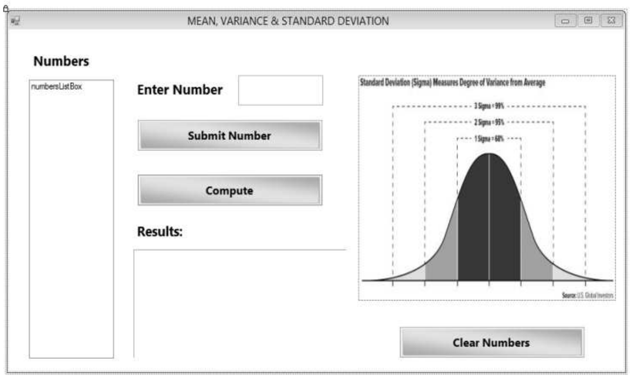

Figure 5: Mean, Variance and Standard Deviation Function

As the program is invoked, the splash screen will display after which the log in screen comes up. The user is asked to enter a username and a password. If the log in details is right, the home page displays. The home page enables the user to select any mathematic simulation of his choice to execute.

Methodology

The methodology followed by this research is the experimental method, which is quantitative in nature. The method is when we change the external environment or create various research scenarios by combining the entities that have expected characteristics (Kaptan, 1998). We studied the effect of using our proposed simulator to boost the academic performance of Junior Secondary School Students 2 (JSS2) students being taught equations, quadratic equation, mean, variance and standard deviation. A JSS2 class of 46 students from a public school was chosen and split into two. The participants from each group were chosen randomly. One half is taught using the classical method and the other half our proposed simulator. The academic performance of the students had been analyzed before and after teaching. A mathematical performance test had been used as pretest and posttest to check the mathematical performance of both the experimental and the control group.

To determine the equivalence of the two different groups, their mathematics pretest scores were compared. Having established their equivalence, one group was randomly taken as the control group and the other the experimental. The average scores of the performance test carried out before teaching the two groups was seen to be close to each other. The mathematical test was used to measure the mathematical performance of the students. The test had 20 multiple choice questions and was prepared by the researchers.

Implementation

Ten days before teaching, a pretest was conducted to the experimental and control group students in the same day and at the same hour. This was done in order to analyze and establish the equivalence of the two groups in terms of mathematical performance and their level of knowledge of the students prior to teaching the topics. The lessons of the both groups were conducted by the researchers throughout the period, so as to provide the same content to both groups.

The students in the experimental group were exposed to the proposed simulator during the 60 hour period inside a computer laboratory. After the teaching period had elapsed, the mathematical performance test, which was used as pretest, was now conducted as a post-test. The effect of the proposed simulator was evaluated by comparing the results obtained with the pretest results.

Item analysis was carried out using ITEMAN analyzing software so as to calculate the reliability of the mathematical performance test. A t-test for two independent samples was performed to analyze the quantitative data collected. SPSS software was then used to determine whether there was a significant difference between the two groups at the significance level of 0.05.

Result and Evaluation

To determine whether there was a major difference between pre-test and post-test mathematical performance, the average scores of the experimental group and control group were analyzed by using a t-test for independent samples. These values are shown in the Table 1 below.

Table 1: The analysis of the difference between pre-test and post-test mathematical performance scores of the students in experimental group

Test	Pretest	Posttest
N	23	23
$\bar{x}$	6.21	6.91
S	2,25	2,27
T	10,948	10,948
Sd	22	22
P	0,000	0,000

Table 2. The analysis of the difference between pre-test and post-test mathematical performance scores of the students in control group

Test	Pretest	Posttest
N	23	23
$\bar{x}$	6.91	13.47
S	2,57	3,28
t	12,322	12,322
Sd	22	22
p	0,000	0,000

Table 3: The analysis of the difference of mathematical performance scores between experimental and control groups before teaching

A. **Group**	*B.* **Experimental**	*C.* **Control**
D. N	*E.* 23	*F.* 23
G. $\bar{x}$	*H.* 6.21	*I.* 6.91
J. S	*K.* 2,25	*L.* 2,57
M. T	*N.* 0,975	*O.* 0,975
P. Sd	*Q.* 44	*R.* 44
S. P	*T.* 0,335	*U.* 0,335

Table 4: The analysis of the difference of mathematical performance scores between experimental and control groups after teaching

Group	**Experimental**	**Control**
N	23	23
$\bar{x}$	16.65	13.47
S	4,55	3,28
T	2,708	2,708
Sd	44	44
P	0,010	0,010

From the above results in Table 1, it could be clearly seen that the mathematical performance pretest average score of the experimental group students is $\bar{x}$ = 6.21 and the mathematical performance post test average score is found to be is $\bar{x}$ = 16.65 in Table 4. It can also be seen that the experimental group students' average score obtained from the mathematical performance post-test is higher than the average score of pretest. It has been found that there is a great difference between mathematical performance pre-test scores and mathematical performance post-test scores of the control group [t(22) =10,948; p< .05], according to the t-test result carried out to determine whether there is a major difference between mathematical performance pre-test and mathematical performance post-test of the experimental group students. This result has revealed that there is a major increase at the performance level of the experimental group students as a result of the teaching.

From the above results in Table 2, it could be clearly seen that the mathematical performance pretest average score of the control group students is $\bar{x}$ = 6.91 and the mathematical performance post test average score is found to be is $\bar{x}$ = 13.47 in Table 4. It can also be seen that the control group students' average score obtained from mathematical performance post-test is higher than the average score of pre-test. It has been found that there is a great difference between mathematical performance pre-test scores and mathematical performance post-test scores of the control group [t(22) =12,322; p< .05], according to the t-test result carried out to determine whether there is a major difference between mathematical performance pre-test and mathematical performance post-test of the control group students. This result has revealed that there is a major increase at the performance level of the control group students as result of the teaching.

To determine whether there is a major difference between the average scores of the experimental and control group students in the mathematical performance test before (pre-test) and after (post-test) the teaching period were analyzed using the t-test for independent samples, as shown in the Table 3 and Table 4.

From the results in Table 3, it could be seen that the mathematical performance before teaching average score of the control group students is $\bar{x}$ = 6.91 and the mathematical performance before teaching average score of the experimental group is found to be is $\bar{x}$ = 6.21. It can also be seen that the control group students' average score obtained from the mathematical performance test before teaching was higher than the experimental group students. It has been found that there is no great difference between the average score of two groups [t(44)=0,975; p> .05], according to the t-test result carried out to determine whether there is a major difference between and before teaching average scores of the experimental and control group students. This result has revealed that the performance level of the experimental group students and that of the control group students before teaching are equivalent to each other.

From the results obtained in Table 4, it is seen that the control group students' average score obtained from the mathematical performance test after the teaching period was calculated as ($\bar{x}$ =13.47) while the experimental group students' average score from the same post-test was calculated as ($\bar{x}$ =16.65). The average score of the experimental group students from the mathematical achievement test after the teaching period is higher than the control group students'. According to the t-test result carried out to determine whether there is a great difference between the post-test average score of the experimental and control group students, it is found that there is a great difference between the average score of the two groups [t(44)=2,708; p< .05]. Based on these findings, it can be said that the difference between the mathematical performance scores of the experimental and control group students is in favor of the experimental group students. This has consequently revealed the impact of our proposed program that simulates elementary mathematics toward boosting the mathematical performance of students.

Conclusion

This proposed program will go a long way in enhancing the mathematical performance of students when utilized to teach them mathematics. It will also serve as computer-aided learning, whereby the students can learn a lot with the aid of a computer program alone. It is highly recommended to schools to incorporate mathematical simulation applications such as this to make mathematics fun and easy to learn. As a future work, we hope to add as many mathematics simulations as possible to this work and possibly numerical iterations.

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